Transit Signal Priority Operations

MTC Arterial Operations Committee

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Presentation Outline

- Overview
- Priority Types
- Detection Technologies
- Operation Scenarios
- Controller Settings/Parameters
- LRT Considerations
- Example Projects

Transit Signal Priority (TSP)

- Goal: Provide preferential treatment to transit vehicles while minimizing impacts on vehicular traffic
- Used for both buses and light rail
- Unlike preemption, TSP does not allow reduction or termination of pedestrian clearance times
- Two Types:
    - Passive
    - Active

Passive Priority

- Signal coordination to favor the progression of transit vehicles without the use of transit vehicle detection technologies or TSP interactions
- Dwell times at stops are estimated to develop the progression schemes
- Used mostly for one-way progression
- Impacts to vehicle progression primarily in the direction opposite to the transit vehicle progression
- Not very reliable

Active Priority

- Uses transit vehicle detection technologies and priority algorithms to service a transit vehicle
- Typically uses early green or green extension to service a priority call
- Two types:
  - Headway-Based
  - Schedule-Based

Headway-based TSP

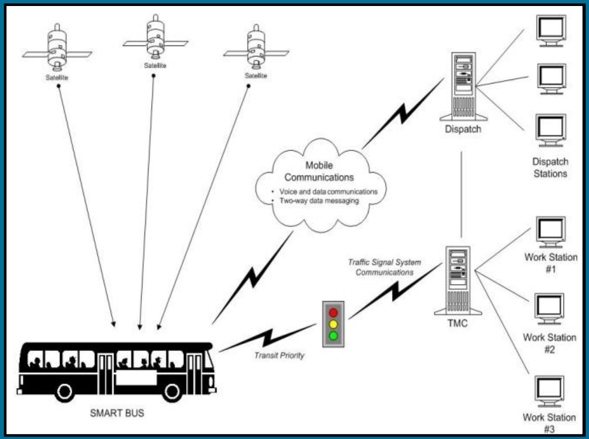
- TSP requests granted based on pre-determined time interval, e.g. every 10 minutes
  - Systems can restrict more than one call within the interval, so TSP preference may not be granted
- TSP emitter is always on
- Simple and cost effective to implement
- *Examples:* San Pablo Avenue, E. 14th/International/ Broadway , Telegraph Avenue, VTA Line #522

Schedule-based TSP

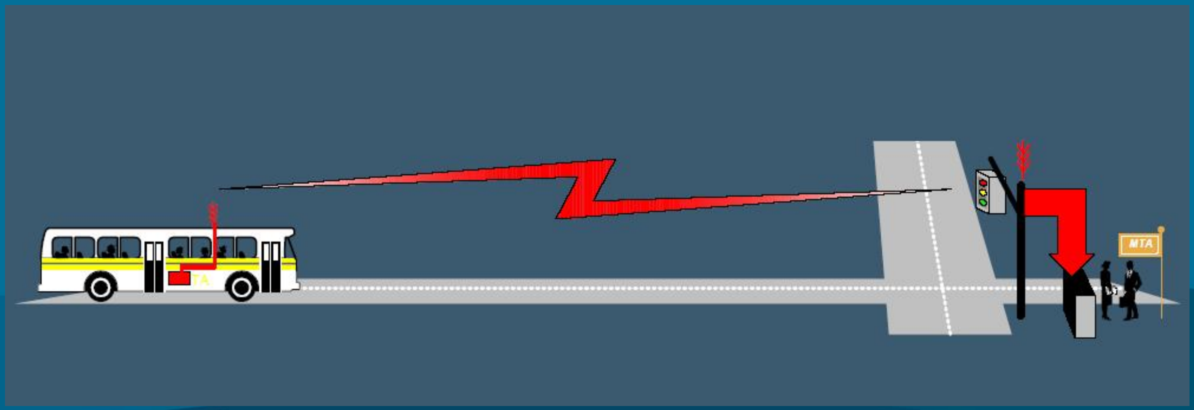
- TSP is requested and granted only when a transit vehicle is behind schedule
- TSP turned on only when needed
- Requires an AVL and scheduling system to determine whether bus is behind schedule

TSP Detection Technologies

- Optical (such as Opticom)
- GPS
- Loop detectors
- Radio



- Signal Interconnect for cascading calls



Cascading Priority Calls

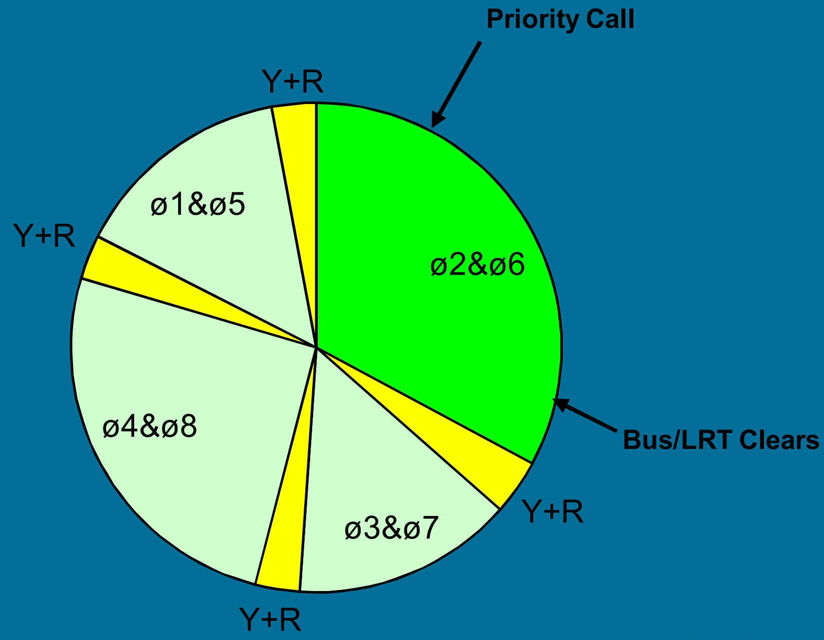
- Sends a TSP call to multiple traffic controllers using interconnect cable
- Upstream traffic controller(s) receives TSP call, processes it, and forwards the TSP to the downstream traffic controller(s)
- Next downstream traffic controller does the same (process and send)
- Provides more time for the traffic controllers to react and service the transit phase

TSP Scenarios

- Do Nothing
- Extended Green
- Early Green
- Early Green – lag left turns
- Transition and Recovery

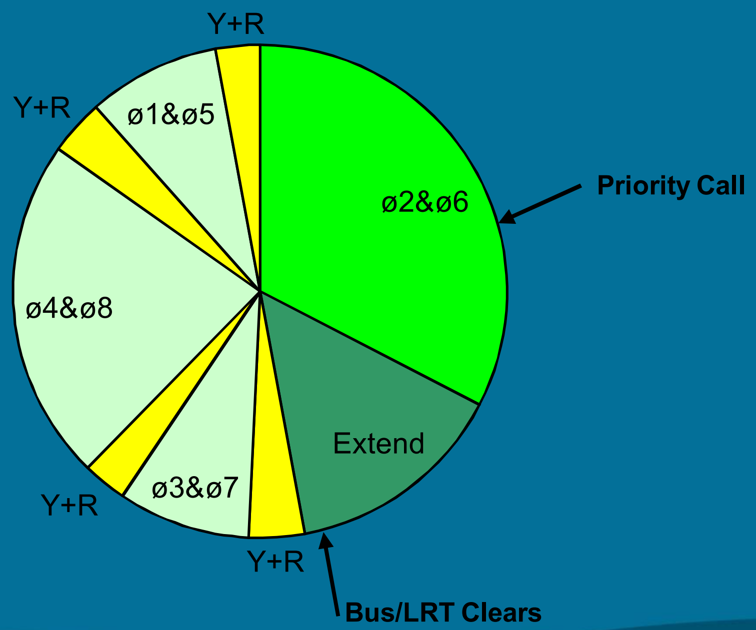
Do Nothing Scenario

- Priority call is placed prior to or during the priority phase, but can clear during the normal split time



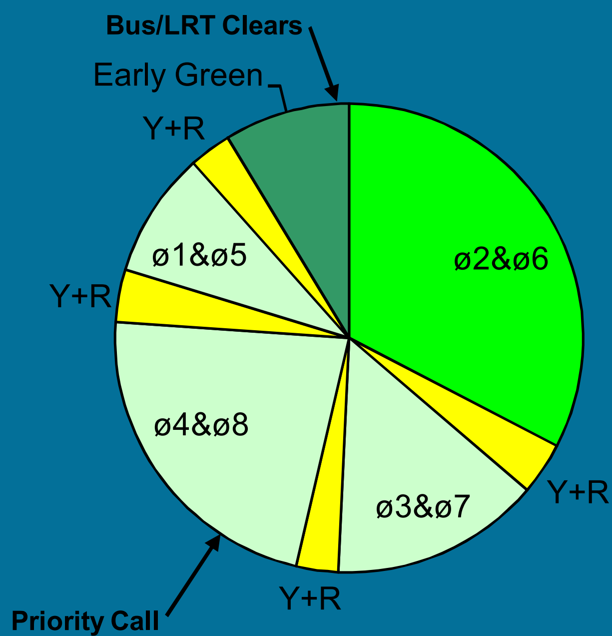
Extended Green Scenario

- Priority call is placed prior to or during the priority phase, but requires extended green to clear the intersection



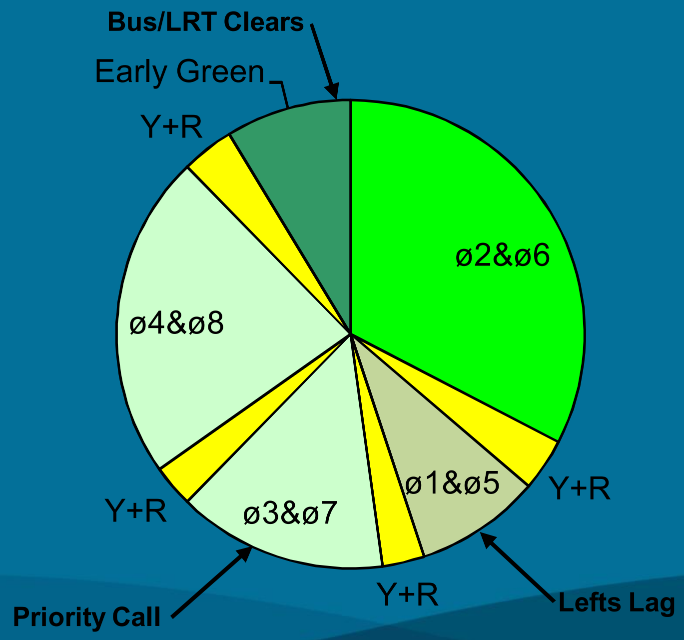
Early Green Scenario

- Priority call is placed when priority phase is not active and therefore the priority phase receives an early green



Early Green Scenario – Lag Left Turns

- Same as early green but the left turns in the priority direction, which normally lead, are lagged during a priority cycle to bring the through phase on early.



Transition and Recovery from TSP

- Varies from one controller software to another
- Early green TSP needs no recovery
  - Controller is back in “sync” at the end of that coordinated green
- Extended green TSP can recover in one of two ways:
  - Shorten the following non-transit phase, or
  - Give the following non-transit phase the full split and shorten the next cycle’s transit phase

Controller Settings

- Can be used in either free or coordinated mode
- Maximum extension or minimum reduction
  - Designate specific priority minimum splits or reduction in split time
  - Maximum reduction of splits as a % of cycle length (Bi Tran and Caltrans)
- Frequency of granting (time or cycles)
  - Weigh expected benefit vs. potential for increased delay

Controller Settings, cont.

- Arrival time
  - Calculate based on where call is placed and transit vehicle travel time (include dwell time)
- Alternative phase sequence during priority cycle (left turns on main street)
- Phase omit (some controllers)
  - Not preferred and consider for very minor movements only
- Time-out setting
  - Controlled by splits or set by travel time

TSP Analysis

- Splits – Early and Extend Times
  - VISSIM or other simulation software
    - With virtual controller software, can accurately evaluate impact on traffic operations.
    - Higher cost to develop.
  - Synchro or other timing software
    - Model “worst case” maximum early green or extended green to determine how much time can be taken from each phase
    - Lower cost to develop
- Travel time and arrival data
  - Controller/system data collection
  - Manual observations at intersections
  - Ride transit vehicles

Special LRT Priority Considerations

- Minimizing LRT delay and stops is critical for system schedules
- Reduction in vehicular splits usually set much higher to minimize LRT delay
- Enabling left turn sequence change can significantly improve operations
- Since early and extended greens are a high % of the cycle, offsets during coordination need to be adjusted
- May require slightly higher coordination cycle and splits to enable phases to “recover” after priority call

San Jose LRT Corridors

- 2070 controllers with D4 software installed, with predictive priority operation
- Calls are cascaded and continually updated as a train arrives at an intersection
- Where coordination did not work effectively with old controllers, the new controllers allowed for coordination with TSP
- Timing updated along LRT corridors including Capitol Avenue, First Street, Second Street, Tasman Drive, San Carlos Street.

San Jose LRT Corridors, cont.

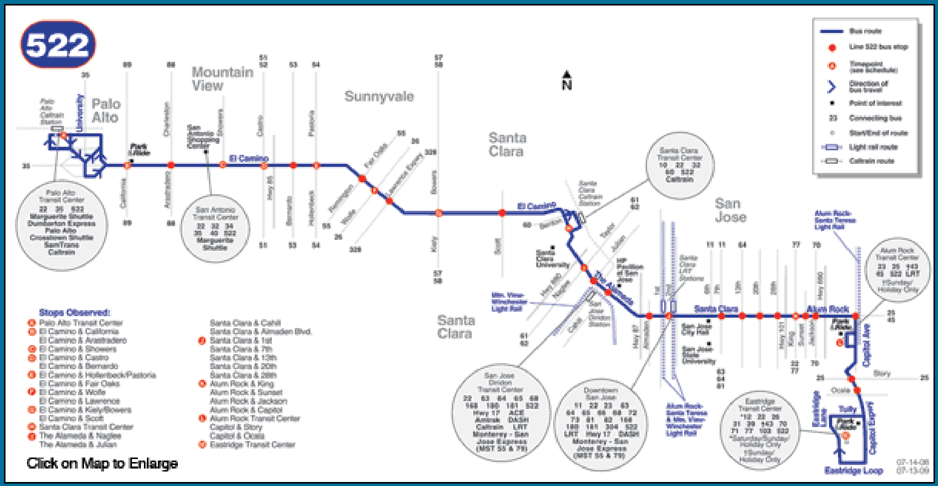
- VISSIM software used for initial operations review, Synchro used for coordination timing and TSP
- Signal coordination implemented in various sections during various times of the day
- Some sections do not warrant coordination, but free operations optimized
- Provided cross coordination on some key roadways

LRT Corridors Performance Measures

LRT Corridors	Time Period	Savings (%)		
		Travel Time	Average Delay	Average Stops
Capitol Avenue (Hostetter Road to Wilbur Avenue)	AM	-14%	-27%	-22%
	PM	-4%	-2%	-1%
McKee Road (Julian Street/28th Street to Jose Figueres Avenue)	AM	-10%	-23%	-19%
	PM	-7%	-15%	-29%
Taylor Street (1st Street to 7th Street)	PM	-58%	-82%	-75%
2nd Street (Julian Street to Reed Street)	AM	-5%	-11%	-13%
	PM	-12%	-33%	-25%
1st Street (San Carlos Street to Tasman Drive)	AM	-18%	-32%	-49%

VTA Rapid 522

- 27-mile long corridor, 6 municipalities
- 8-minute headways
- El Camino Real from Palo Alto Transit Center to Race St.
  - Primarily Caltrans controlled
  - Loop based detection technology
  - 2 queue jump locations
  - 18.4% reduction in travel time
- The Alameda, Santa Clara Street, Alum Rock from Race Street to Capitol Avenue
  - City of San Jose and Caltrans controlled
  - GPS based detection technology
  - Analysis completed in Synchro (splits by Time-of-day)
  - Calls cascaded between signals in San Jose
  - 23.0% reduction in travel time



Note: Study results and map provided by VTA

Montague Expy./N. First St. LRT

- Study funded by TETAP
- Operation changed to low priority (TSP) from high priority operation
- Ability to coordinate on Montague Expressway in the AM and PM peak periods
- Significant fine-tuning efforts to balance vehicular operations with LRT delay

Montague /N. First Study Results

- Montague Expressway Results
  - Average vehicular delay on Montague reduced 23% to 66%
  - Observed maximum vehicle queuing reduced on all approaches
  - Estimated total yearly fuel savings of ~100,000 gallons during AM and PM period

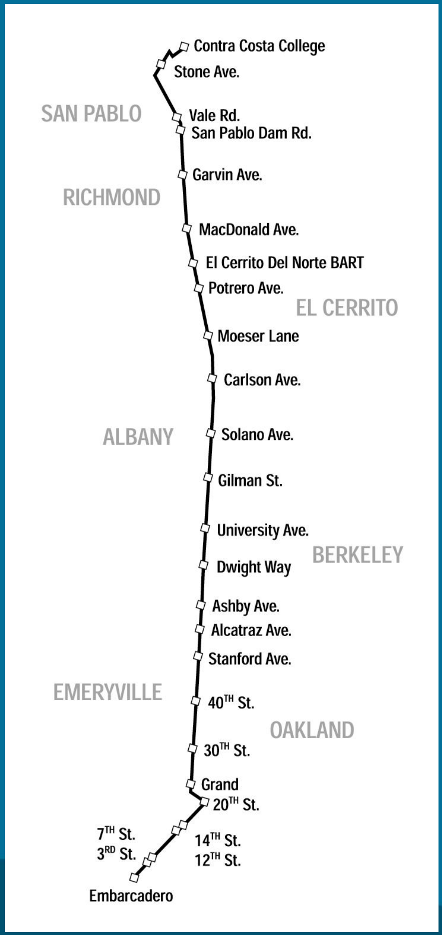
Peak Period	Average Delay (seconds per vehicle)				% Difference		Total Yearly Delay Savings (vehicle-hour)	Total Yearly Delay Savings (person-hour)
	Before		After					
	WB	EB	WB	EB	WB	EB	WB/EB	WB/EB
AM	112	43	44	33	-60.7%	-23.3%	18,655	20,520
PM	89	50	31	17	-65.2%	-66.0%	27,390	30,130

- Light Rail Transit Results
  - 47% of the trains did not stop
  - Average delay increased to ~28 seconds, from under 5 seconds

Peak Period	Average Delay (seconds per train)				Occupancy (person per hour)		Total Yearly Delay Increase (person-hour)
	Before		After		NB	SB	
	NB	SB	NB	SB			NB/SB
AM	3.9	3.4	28.6	27.5	190	185	1,270
PM	1.0	3.1	22.4	32.7	220	295	1,865

San Pablo Avenue BRT

- 14-mile long corridor
- Includes 7 cities in 2 counties
- Used 10% of cycle for priority
- Optical detection technology
- 17% reduction in travel time
- 77% increase in ridership



Questions?

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